

STATUS OF THE SALTWATER CROCODILE (*CROCODYLUS POROSUS* SCHNEIDER) IN THE BHITARKANIKA WILDLIFE SANCTUARY, ORISSA, INDIA¹

S.K. KAR² AND H.R. BUSTARD³
(With four text-figures)

The status of the saltwater crocodile in the Bhitarkanika Sanctuary of Orissa was determined by combined day and night counts. The adult population (29 individuals) was extremely low, and subadults numbered only six, indicating very poor recruitment in recent years. However, the number of juveniles (61) was good, indicating the likelihood of better recruitment in the years ahead. This enhanced survival of juveniles is a result of management activities, particularly banning the use of nylon gill nets throughout the Sanctuary. A preliminary attempt was made to correlate crocodile numbers with features of the habitat. The mean density for all non-hatchling size classes was 0.87 individual/km.

INTRODUCTION

The saltwater crocodile in India suffered a dramatic decline in numbers as a result of a combination of poaching and habitat loss (Bustard 1974). The mangrove ecosystem, to which this species is tied in India, is one of the country's most threatened ecosystems. Once cleared and bunded, the fertile alluvium built up by the mangroves provides rich agricultural land. There was a long tradition of bunding and farming on the landward side, combined with rigid protection of the mangrove forests themselves under the Raja of Kanika in Orissa. The mangroves slowly reclaimed land from the shallow waters of the Bay of Bengal and protected the coastline from cyclonic damage. The problem now is that population pressure on good agricultural land combined with the need for fuel wood has resulted in increasing destruction of the mangrove forests.

The rarity of the saltwater crocodile in India was apparent by the late 1960s (Daniel 1970). Bustard and Choudhury (1981) pointed out that the saltwater crocodile is now extinct in the South Indian states of Kerala, Tamil Nadu and Andhra Pradesh, restricted to the Bhitarkanika Wildlife Sanctuary in Orissa, and very rare in the Sundarbans in West Bengal.

Bhitarkanika has been renowned for its

saltwater crocodiles. Daniel and Hussain (1975), based on field work during 1973, recorded the continued existence of the Bhitarkanika population of the saltwater crocodile and pointed out the need to stop all felling of mangroves if the habitat for the crocodiles was not totally to disappear.

Bustard (1974) strongly recommended that this area be declared a Sanctuary, and then managed in the interests of the crocodile. Bustard also highlighted the need to protect the mangroves, recommending a total ban on their felling. A similar recommendation was also made by de Waard (1975). At this time the State Forest Department was opening coupes for working by the local people on a 5 year rotation cycle. Such a short rotation cycle (the normal one is 20 years) was contributing to the destruction of the mangrove forests. Furthermore, Bustard pointed out the necessity of stopping all fishing within the area, especially a serious threat to recruitment in the crocodile population, an observation since confirmed (Kar 1981).

The State Government of Orissa accepted these proposals. The area was gazetted a Sanctuary on 22 April 1975; in the following month, fishing was banned throughout the Sanctuary. In 1975, the State Government of Orissa set up a Saltwater Crocodile Research and Conservation Centre at Dangmal in the heart of the Sanctuary with the purpose of quickly multiplying the population using the 'grow and release' techniques for archaic reptiles as recommended by Bustard (1974). An early account of this work is given in Bustard (1975). In 1976, following consideration of the above reports, and advice from the Government of India, the State Government of Orissa completely stopped all fell-

¹Accepted July 1986.

²Office of the Chief Wildlife Warden, Orissa, 315-Kharaval Nagar, Bhubaneswar-751001, Orissa, India.

³Ex-Chief Technical Advisor to Government of India. Present Address: Airlie Brae, Alyth, Perthshire, Scotland, PH11 8AX (UK).

ing of mangroves.

The saltwater crocodile population was known to have suffered heavy exploitation in the past but no data were available as to its present status. The present paper describes the results of a detailed census carried out throughout the Sanctuary in the period 1 December 1976 to 30 January 1977.

Surveys for saltwater crocodiles were reported on by Bustard (1967, 1970) for Papua New Guinea and Western Australia respectively. Survey methods for *C. porosus* in Australia have been discussed by Messel (1977) and Messel *et al.* (1978) as the basis for extensive surveys of the saltwater crocodile resource of Northern Australian river systems. These methods were then used as a basis of at least 14 monographs now in print, in press, or in preparation, under a general title "Surveys of Tidal River Systems in the Northern Territory of Australia and their Crocodile Populations", plus two monographs referring to selected rivers in Western Australia (Messel *et al.* 1977, Burbidge and Messel 1979).



Fig. 1. Map of India showing location of Orissa and the Bhitarkanika Sanctuary (solid black circle).

THE SANCTUARY

The Sanctuary, comprising 176 sq.km of Reserve and Protected forests, is located in the deltaic region of the Bitarani-Brahmani rivers in Cuttack District, Orissa (Fig. 1). The habitat consists of deltaic mangrove swamps growing on rich alluvium. Some areas have been bunded for cultivation purposes, in all unbunded areas, however, mangrove vegetation is dominant.

Annual rainfall averages 1670 mm/annum with the main rainfall occurring during the monsoon months of August and September. In summer the temperature range is from the high 30°C to high 20°C (day and night respectively) whereas during the short winter it is upper 20°C to 15-20°C respectively. The mangrove habitat is intersected by numerous creeks and creeklets, the water flow in which is influenced twice daily by the tide.

The main mangrove species are *Avicennia alba* (a first coloniser), *Avicennia officinalis*, *Rhizophora mucronata*, *Excoecaria agallocha*, *Acanthus ilicifolius*, *Sonneratia apetala* and *Heritiera minor*. The palm *Phoenix paludosa*, the fern *Acrostichum aureum*, and *Hibiscus tiliaceus* are widespread throughout the mangrove forests.

The human population of the Sanctuary and of the villages in the area adjacent to the Sanctuary totals 354,000, resulting in considerable encroachment problems.

The mammalian fauna includes the leopard (*Panthera pardus*), striped hyaena (*Hyaena hyaena*) and the lesser cats (*Felis chaus*, *F. bengalensis*); spotted deer (*Cervus axis*), sambar (*Cervus unicolor*) and wildboar (*Sus scrofa*). Large troops of rhesus macaque (*Macaca mulatta*) also occur in the Sanctuary. Both deer species, wildboar and macaques are taken by crocodiles (Kar and Bustard 1981). The larger reptiles include the Indian Python (*Python molurus*) and the monitor lizards (*Varanus salvator*, *V. flavescens* and *V. bengalensis*). The avifauna is rich and varied (Kanungo 1976).

METHODS

Winter was chosen for the survey as during the short winter in coastal Orissa, extending from late November to mid-February, the larger saltwater crocodiles bask regularly, whereas at other times of

the year basking by these large individuals is reduced and sporadic (Kar 1981). Diurnal enumeration during basking is the only reliable method of censusing large crocodiles in the Sanctuary (see Discussion). Furthermore, during the winter, the postcrepuscular activity is telescoped into two to three hours following dusk allowing effective census of juveniles and immature year classes. Extensive field work in the Sanctuary has shown that night spotting is the effective method of censusing juveniles and subadult year classes (see Discussion).

Diurnal census was carried out during the basking hours each morning (0800-1100 hrs.) and night spotting between 1800 and 2100 hrs., at which time the crocodiles are likely to be present at the surface close to the bank in maximum numbers. During the day, it was a straight-forward matter to estimate the size of crocodiles sighted. Crocodiles of under 0.6 m do not bask and individuals of between 0.6-1 m could be estimated within 0.5 m. At night, using a powerful spotlight it is possible to approach light-blinded juveniles provided silence is maintained and experienced people control the boat and spotlight. However, only individuals of less than 2 m can be sighted at night with any regularity. Such individuals can usually be approached to within touching distance permitting at least as accurate size estimation as during the day. Adult crocodiles are very rarely seen during night spotting.

All census work here reported was carried out by boat, no other method being practicable due to the dense mangrove forest fringing the creeks. Local country boats used in the normal protection patrols within the Sanctuary were used for the census. These vessels are eight metres overall and are crewed by three boatman - two on the oars and one on the rudder. One of us (S.K.K.) operated the sealed beam, pre-focused spotlight as used by the Indian Navy and powered by a 12 volt car battery.

At night the tapetum of the crocodile's eyes reflect light enabling individuals floating at the water's surface (the normal alert posture after dark) to be sighted at distances of over 0.5 km with a powerful spot. The colour of the reflection enables an experienced observer to make a preliminary estimate of the size. The reflection of small crocodiles is pinkish in colour, becoming more reddish as the crocodiles grow. Very large crocodiles reflect a very dark red. However, all size estimates given in this

paper were confirmed by close approach.

Familiarity with the habitat will greatly enhance the accuracy of survey results. We have intimate knowledge of the river and creek systems of the Sanctuary which are regularly patrolled using the same 'country boats' used in the actual survey work.

Survey in tidal rivers and creek systems, irrespective of whether they are conducted by day or by night, are greatly affected by the state of the tide. When the tide is high crocodiles will be missed:

- (a) by day because the basking mudbanks will be inundated and any crocodile which has emerged will be within the vegetation zone where they are likely to be missed.
- (b) at night because smaller crocodiles (less than 2 m) usually remain close to the creek-banks. When the tide is high the reflection of their eyes may be hidden by overhanging vegetation and if the tide has flooded the bank these crocodiles may be in the vegetation zone itself.

In either situation the eye reflections are likely to be missed. Accordingly all surveys were carried out when the tide was half tide or less, that is when there was a drop of at least 1.6 m from the fortnightly high tide level.

In night survey work it is important to carry out the surveys during the darker phases of the moon. Nights on which work can be completed prior to the moon rising are best. When the moon is visible and there is little or no cloud cover, good results cannot be expected with a moon more than one-quarter full, since the spotlight is less effective under such conditions and the crocodiles are more likely to detect the approaching vessel (and hence not permit close approach).

Using the above techniques, it was readily possible to bring the dinghy to within 1.5 m or less of crocodiles of below three years of age (1.2-1.4 m) and to within 6 m or less of larger subadults.

There is no external sexual dimorphism in the saltwater crocodile. However, there is a marked difference in size between the sexes. Females do not exceed a total length of 4 m whereas males grow to in excess of 7 m and the average size of males within the Sanctuary is 5.5 m. All crocodiles in excess of 4 m were scored as males, and crocodiles in excess of 2.5 m but below 4 m scored as females. This method gives a much more accurate separation of the

sexes
TABLE 1
CROCODILE POPULATION IN RELATION TO HABITAT. RIVER DISTANCES (KM), SEX OF ADULTS BRACKETED (M, F).

| Number | Location | | | Habitat Ranking | | | Crocodiles Present | | |
|--------|----------|-------|-----------|-----------------|-------|---------------|--------------------|-----------|-------|
| | Length | River | Mangroves | Disturbance | Total | Adults | Sub-adults | Juveniles | Total |
| 1. | 6.2 | 1 | 1 | 1 | 3 | 0 | 2 | 1 | 3 |
| 2. | 12.4 | 3 | 3 | 3 | 9 | 2 (1M, 1F) | 0 | 3 | 5 |
| 3. | 7.8 | 3 | 3 | 3 | 9 | 2 (1M, 1F) | 0 | 15 | 17 |
| 4. | 7.5 | 3 | 3 | 3 | 9 | 4 (2M, 2F) | 0 | 10 | 14 |
| 5. | 8.7 | 2 | 2 | 2 | 6 | 1 (M) | 2 | 16 | 19 |
| 6. | 12.8 | 3 | 3 | 1 | 7 | 5 (3M, 2F) | 0 | 2 | 7 |
| 7. | 6.7 | 3 | 3 | 3 | 9 | 2 (1M, 1F) | 1 | 5 | 8 |
| 8. | 10.0 | 2 | 1 | 1 | 4 | 3 (2M, 1F) | 0 | 2 | 5 |
| 9. | 7.5 | 1 | 1 | 1 | 3 | 2 (1M, 1F) | 0 | 4 | 6 |
| 10. | 8.0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| 11. | 1.5 | 2 | 0 | 1 | 3 | 1 (M) | 0 | 1 | 2 |
| 12. | 23.0 | 2 | 3 | 2 | 7 | 3 (2M, 1F) | 1 | 2 | 6 |
| 13. | 11.0 | 2 | 1 | 0 | 3 | 1 (F) | 0 | 0 | 1 |
| 14. | 7.5 | 2 | 2 | 1 | 5 | 3 (1M, 2F) | 0 | 0 | 3 |
| Total | 130.6 | - | - | - | - | 29 (16M, 13F) | 6 | 61 | 96 |

within the Sanctuary than might be anticipated, since as a result of severe hunting in the past, almost all the present adults are older individuals which have survived by becoming extremely wary. In the case of males, this means that they have attained a very large size.

Concurrent with the census, the major components of the habitat were evaluated. For the crocodiles, these are considered to constitute the river, the fringing mangrove forests, on which depends the creation of mudbanks for basking, as well as the cover so essential for young crocodiles and for nesting and the degree of human disturbance. These were scored 0 - 3. Where the river was very poor, the mangrove cover had been completely lost, or human disturbance was maximum, a score of 0 was given with an ascending score for progressively better habitats.

RESULTS

The Crocodile Population

Details of individuals recorded during the survey are given in Table 1 which also summarizes the results of the habitat evaluation discussed above. Although individuals between 0.8 and 2 m may represent six year classes, the majority of juveniles in the Sanctuary are the progeny of the 1974 and 1975 nesting seasons which have survived as a result of Sanctuary gazettement, especially the banning of set gill nets. The individuals referred to as juveniles in Table 1, totalled 61. Those in the 1.6 - 3 m size

class comprise six subadult individuals (size range 1.6 - 2.1 m) together with individual considered to be a female. In the 3-4 m size class, it is thought that all are females. As described above, those in excess of 4 m are considered to be males. The presence of 11 individuals between 5-7 m, all of which are undoubted males, should be noted.

Table 1 indicates that adult males slightly exceed adult females numerically, that subadult (six) are very few in number, and that juveniles (61) account for more than 63.5% of the population, being more than twice as numerically abundant as adults.

The distribution of the population

The numbers refer to habitat areas (Figs. 2-4).

Location 1: This area is considered unsuitable for permanent residence by adults due to the excessive water flow (the left hand portion was a man-made cut dug to improve the water flow in the main river system and for easier transportation of goods). The mangroves are degraded on one bank.

Crocodiles present: Adult - 0, Subadults - 2, Juveniles - 1.

Location 2: This creek system provides good habitat with good mangrove cover.

Crocodiles present: Adults - 2 (one male and one female), Subadults - 0, Juveniles - 3.

Location 3: Good habitat. Very low human disturbance. Good mangrove cover.

Crocodiles present: Adults - 2 (one male, one female), Subadults - 0, Juveniles - 15.



Fig. 2. The creek systems in the heart of the Sanctuary.

Location numbers refer to the text. The lines bisecting the creeks indicate the limits of each numbered location.

Location 4: Very good habitat with excellent mangrove cover. Low human disturbance.

Crocodiles present: Adults - 4 (two males, two females), Subadults - 0, Juveniles - 10.

Location 5: Good habitat. Good mangrove cover, especially on interior side. Some human disturbance.

Crocodiles present: Adults - 1 male, Subadults - 2, Juveniles - 16.

Location 6: Excellent habitat, good mangrove cover. Some human disturbance.

Crocodiles present: Adults - 5 (three males, two females), Subadults - 0, Juveniles - 2.

Location 7: Very good habitat, good mangrove cover. No human disturbances.

Crocodiles present: Adults - 2 (one male, one female) Subadults - 1, Juveniles - 5.

Location 8: Habitat no longer good. Mangrove cover totally absent on outer bank and on interior

bank is poor. Substantial human disturbances.

Crocodiles present: Adults - 3 (two males, one female), subadults - 0, Juveniles - 2.

Location 9: Habitat now poor due to high level of human disturbance. Mangrove cover becoming degraded. At low tide water depth is very low.

Crocodiles present: Adults - 2 (one male, one female), Subadults - 0, Juveniles - 4.

Location 10: Habitat poor since the river system is dry at low tide. Mangrove vegetation absent on outer bank and poor on interior. Much human disturbance.

Crocodiles present: No crocodiles of any size class.

Location 11: This area no longer offers any good habitat. Substantial human disturbances with cultivation right to river bank.

Crocodiles present: Adults - 1 (Male), Subadults - 0, Juveniles - 1.

Location 12: River habitat good. Excellent

mangrove cover. Low human disturbance.

Crocodiles present: Adults - 3 (two males, one female), Sub-adults - 1, Juveniles - 2.

Location 13: Good river habitat spoiled by maximum human disturbance and with poor mangrove cover.

Crocodiles present: Adults - 1 (female), Subadults - 0, Juvenile - 0.

Location 14: Good river. Northern bank completely denuded of mangroves with much illicit felling on the southern bank. The reserve forest of Kalibhanjadian has been subject to heavy illegal felling. Human disturbance high, particularly on the northern bank which has been developed into a fishing port. Disturbance on Kalibhanjadian Island is much less.

Crocodiles present: Adults - 3 (two females, one male), Subadults - 0, Juveniles - 0.

The above information is summarized in terms of habitat ranking of the river, mangroves and degree of disturbance in Table 1. Table 2 gives the density of the total crocodile population (number/km) in their fourteen areas of the Sanctuary. The crocodile density varies from 0/km to 2.18/km (mean 0.87). This is an extremely low figure (see Discussion).

DISCUSSION

The topics for discussion fall into four main categories (1) survey techniques, (2) the crocodile population, (3) the distribution of the population in relation to habitat, and (4) implications of the above three topics for/in management of this crocodile Sanctuary.

1. Survey Techniques.

The techniques used here, are based on Bustard's 15 years' experience of *C. porosus* in the Asian/Pacific region with suitable modifications for local conditions. The survey was more intensive than those reported previously by Bustard (1967 : 1970) or those of Messel *et al.* (see Introduction). This was possible since the area studied is relatively small and has been the subject of continuous monitoring since 1975.

It was found that effective census of this population of saltwater crocodile required a combination of diurnal and night-spotting techniques.

TABLE 2
NUMBERS AND DENSITIES OF CROCODILES IN THE VARIOUS
HABITATS. DISTANCES (KM), DENSITY/KM.

| Location | | Crocodiles | |
|----------|--------|--------------|---------|
| Numbe | Length | Total Number | Density |
| 1. | 6.2 | 3 | 0.48 |
| 2. | 12.4 | 5 | 0.40 |
| 3. | 7.8 | 17 | 2.17 |
| 4. | 7.5 | 14 | 1.86 |
| 5. | 8.7 | 19 | 2.18 |
| 6. | 12.8 | 7 | 0.54 |
| 7. | 6.7 | 8 | 1.19 |
| 8. | 10.0 | 5 | 0.50 |
| 9. | 7.5 | 6 | 0.80 |
| 10. | 8.0 | 0 | 0 |
| 11. | 1.5 | 2 | 1.33 |
| 12. | 23.0 | 6 | 0.26 |
| 13. | 11.0 | 1 | 0.09 |
| 14. | 7.5 | 3 | 0.40 |
| Total | 130.6 | 96 | 0.87 |

Either approach by itself did not give an adequate census figure of both the adult and the juvenile/subadult components of the population. In Bhitarkanika, in the case of large crocodiles, the eyes are not even observed at a distance during night surveys. This is because adults have learned to submerge immediately they hear the sounds of a boat or see a light (even before the light strikes their eyes). This reflects learning (Bustard 1968), as a result of experience gained during previous human hunting activities. So, although night-spotting gives a much better guide to the number of immature crocodiles present (m) than during day-spotting, the latter is the only way to census the adult cohort of the population.

At night all large adults come into the "eyes only" category of Messel *et al.* We feel that Messel's workers could get much more reliable data on large animals - both on their numerical abundance and their size (that is detailed clarification of the "eyes only" category, which in some of their surveys form an important part of the whole) - by using combined data from day and night censuses as carried out here. Furthermore, it is important to standardize not only the methodology of the census but also the time of the year of censusing, if subsequent recensuses are to be compared with the original census data in any meaningful way. We recommend carrying out the censuses only during winter (as done here) at the time of maximum basking by large adults and at a time when evening activity is concentrated into a

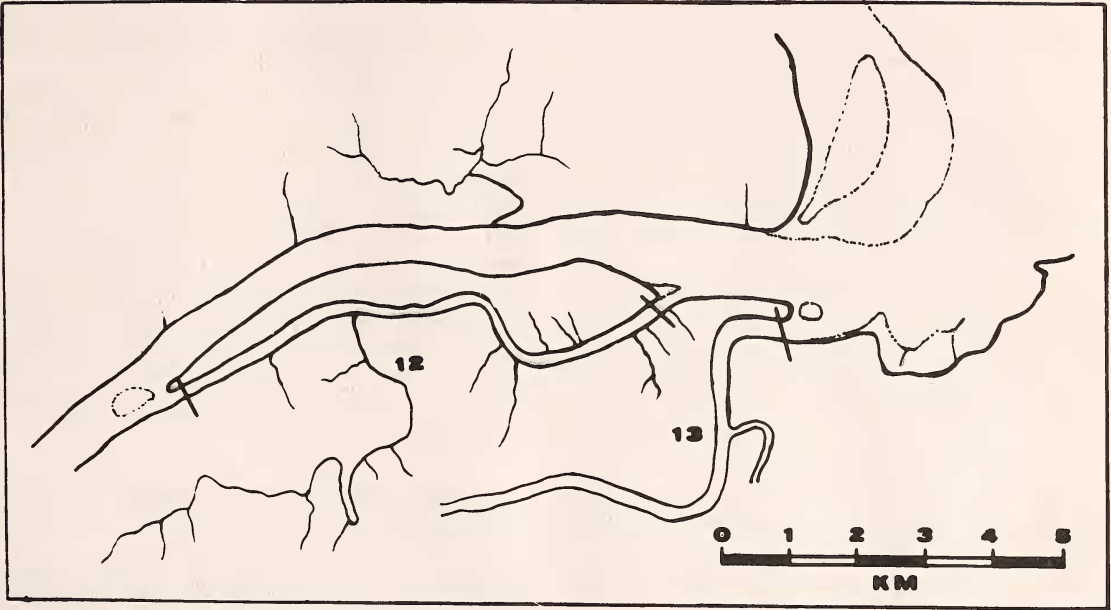


Fig. 3. Larger river systems towards the coastal side of the Sanctuary. Location numbers in the text.

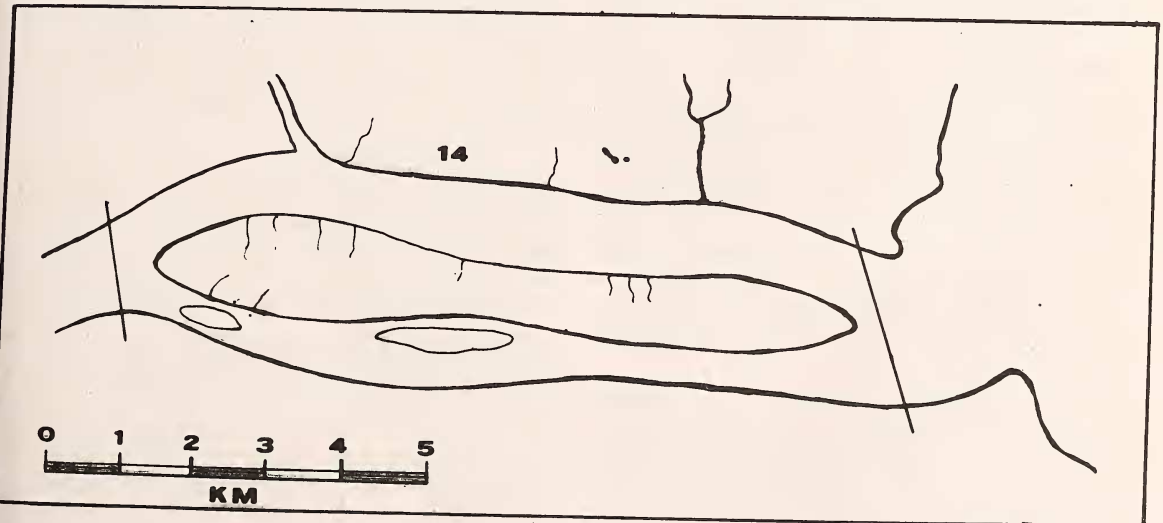


Fig. 4. The major river system at the extreme north of the Sanctuary. Location number in the text.

narrow time span probably resulting in more total coverage of the available population.

We also stress that increased population counts could well result from intimate familiarity with the habitat, and that phase of the moon *per se* (that is the effect of moonlight as opposed to the moon's effect on the tides) is important. Surveys should ideally be carried out in the dark phase of the moon or when the moon is less than full. We agree with Messel *et al* that proper counts cannot be carried out at high tide when the water has overflowed the bank and is in the vegetation zone. We operate only when the water is at least 1.6 m below the fortnightly high tide level whereas Messel *et al* do not commence survey until the water level has dropped 60 cm below a hypothetical line demarcating vegetation for the exposed mudbank. This hypothetical line is placed so that approximately as much vegetation remains below as mud is exposed above it.

Due to the intensive nature of the study being conducted at Bhitarkanika we are able to check and fully corroborate the survey data on the basis of regular basking sightings, nesting female numbers etc.

2. Crocodile Population.

The population is characterised by a numerical excess of males over females (16 as compared to 13). Under natural conditions (a population without a recent history of hunting) we would expect 16 adult males to be associated with at least 30 breeding females. The paucity of females in Bhitarkanika is thought to reflect differential human predation on females as compared to males. Females are readily killed at the nest (Bustard 1967, Bustard and Choudhury 1980, 1981). As mentioned above, at other times the adults are very vary, making capture extremely difficult as hunting methods in this area prior to its gazettelement as a Sanctuary were by torch at night.

The number of subadults (six) is extremely low. This is considered to reflect very high loss levels of 2-3 years old as a result of use of set gill nets in this area until recently. This practice was stopped at the time of Sanctuary declaration when a total ban was placed on fishing within the Sanctuary (May 1975, see below). The population of juvenile *porosus* (mostly in their second and third years) has increased many-fold as a result of good survival of

the 1974 and 1975 hatching year classes following cessation of fishing (see Section 4 and Kar 1981). This should result in greatly enhanced survival of subadults in the future, particularly since the adult population is numerically so depressed.

The overall abundance in the numbers of *C. porosus* (other than hatchlings) in Bhitarkanika at 0.87 individuals/km is of a similar order to the data of Messel *et al.* (see for instance Monographs 3, 4, 5 and 7). Since these figures are enhanced by approximately 50% by better recruitment of juveniles, the figures prior to commencement of management of the Sanctuary must have been approximately 0.4 km. Messel, Gans, Wells & Green (1979) gave comparable figures of respectively 0.48 and 0.55/km for the Victoria and Fitzmaurice rivers of the Northern Territory of Australia.

3. Distribution of the population in relation to the habitat.

If the three habitat criteria of the river, the mangroves and disturbance are examined together the correlation between the apparent 'health' of the habitat and the density of crocodiles/km (total figures for all size classes) is not well marked. There was a good correlation between river characteristics and density (Table 1), as would be expected. There was also some correlation between the degree of disturbance and crocodile population density. There was no apparent correlation between crocodile density and mangrove cover.

Examining the number of adults in relation to the habitat ranking, it was found that a low habitat ranking was associated with a low number of adults/habitat. However, when the habitat ranking was high the number of adults/habitat could be either high or low. One possible explanation for the persistence of adults in poor habitat areas would be that they took up their present home range when the non-river components of the habitat were much different from what they are today. The habitat changes, as they affect the mangrove forests and degree of disturbance have changed drastically in the last two decades, which probably reflect a short time span in the life of an adult saltwater crocodile. For examination of the data for juveniles showed a close agreement with that for adults which may be anticipated since juveniles can only occur in the

presence of adults and dispersal to more favourable habitats had not occurred in this size class. Unfortunately the extremely limited number of subadults (six) precludes correlation analysis of their presence with habitat factors. It should be noted, however, that of the six subadults two occurred in location 1 in the absence of any adults and a further two in location 5 in the absence of any adult females. The remaining two occurred in separate habitats where there were one male and one female and two males and one female respectively. Thus their recruitment may perhaps be enhanced in the absence of adults, particularly females. However, due to the very low number of subadults this can only be conjecture at this stage.

4. Implications of the above three topics for management of this crocodile Sanctuary.

The total crocodile population is very low. The adult cohort of the population is miniscule. There are virtually no subadults. The only hope for the population lies in the survival of the present young crocodiles and their recruitment to the breeding population combined with the release of captive-reared crocodiles back into the wild when they have reached a size at which they are safe from most potential predation in order to boost this recruitment. Hence, if the crocodile population is to survive, let alone recover, both the habitat and the crocodile will require very rigid protection together with the removal of all inimical factors (see Recommendations).

There is a sexual imbalance in the small population of adult crocodiles, resulting in the need to build up the female cohort of the population. This is being done by releasing mostly young females from the Dangmal Centre (Kar and Bustard, in prepn.)

Survival prognosis for the immature crocodiles, resulting from both natural recruitment and release from captivity, is now good as a result of the banning of nylon gill nets throughout the Sanctuary. This is borne out by the sighting of no less than 61 crocodiles in the 1-1.5 m size class

within the Sanctuary (Kar and Bustard, in prepn.). These individuals represent the hatching predominantly of the 1975 year class and to a lesser extent 1974. The virtually complete loss of the previous year classes as a result of their capture in fishing nets prior to banning of fishing throughout the Sanctuary in April 1975 should be noted. Whereas the six subadults represent at least six year classes indicating a survival of the order of only one per year, the 61 individuals represent only two year classes indicating a survival of about 30 individuals/year, an increase of 30 times over the previous figure when nylon gill nets were in use. The implications of this in management are obvious - it is essential to retain the legal ban on fishing in the Sanctuary and to ensure that under the new management plan this ban is effectively enforced throughout the Sanctuary.

The habitat degradation which has taken place may not yet be fully reflected in the numbers of adult crocodiles present as there is likely to be a time lag in that existing crocodiles continue to inhabit their traditional home range however degraded. It may not be possible, however, for new recruitment to take place under such conditions. Hence the situation facing the saltwater crocodile population of the Sanctuary may be even more critical than it appears.

RECOMMENDATIONS

1. The ban on the use of set gill nets throughout the Sanctuary should be maintained.
2. No further encroachment on the mangrove habitat within the Sanctuary should be permitted.
3. This Sanctuary, as a unique floral/faunal ecosystem, should be declared as a Biosphere Reserve by the Government of India.

ACKNOWLEDGEMENTS

We wish to express our thanks to the Orissa Forest Department, the Government of India, F.A.O. and U.N.D.P. for assistance.

REFERENCES

BURBIDGE, A.A. & MESSSEL, H. (1979): The status of the saltwater crocodile in the Glenelg, Prince Regent and Ord River System, Kimberley, Western Australia. Department of Fisheries

and Wildlife. Western Australia Report No. 34: 1-38.

BUSTARD, H.R. (1967): Report on the Crocodile Skin Trade in the Territory of Papua and New Guinea with Recommenda-

tions for the Future Development of the Industry. Unpublished confidential report to Australian Minister of External Territories.

------(1968): Rapid learning in wild crocodiles (*Crocodylus porosus*). *Herpetologica* 24(2): 173-175.

------(1970): Report on the current status of crocodiles in Western Australia. Department of Fisheries and Fauna. Government of Western Australia, Report No. 6: 1-29 pp. + 5 Appendices.

------(1974): A preliminary survey of the prospects for crocodile farming (India). FO:IND/ 71/-033 October 1974. FAO, Rome.

------(1975): Gharial and crocodile conservation management in Orissa (India). *ibid.* December 1975. FAO, Rome.

BUSTARD, H.R. & CHOUDHURY, B.C. (1981): Conservation future of the saltwater crocodile (*Crocodylus porosus* Schneider) in India. *J. Bombay nat. Hist. Soc.* 77(2): 201-214.

CHOUDHURY, B.C. & BUSTARD, H.R. (1980): Predation on natural nests of the saltwater crocodiles (*Crocodylus porosus* Schneider) on North Andaman Island with notes on the crocodile population. *ibid.* 76(2): 311-323.

DANIEL, J.C. (1970): A review of the present status and position of endangered species of Indian reptiles. In Proceedings of the IUCN 11th Technical Meeting, New Delhi. IUCN Publications New Series No. 18: 75-76.

DANIEL, J.C. & HUSSAIN, S.A. (1975): A record (?) saltwater crocodile (*Crocodylus porosus* Schneider). *J. Bombay nat. Hist. Soc.* 71 (2):309-312.

DE WAARD, J.N. (1975): Economic potential of gharial and saltwater crocodile schemes in Orissa (India) with notes on

the sea turtle industry. FO:IND/71/033. Project Working Document. FAO, Rome.

KANUNGO, B.C. (1976): An Integrated Scheme for Conservation of Crocodiles in Orissa with Management Plan for Satkoshia Gorge and Bhitarkanika Sanctuaries. Forest Department, Cuttack, Orissa.

KAR, S.K. (1981): Studies on the saltwater crocodile (*Crocodylus porosus* Schneider). Ph.D. Thesis submitted to Utkal University, Orissa, India.

KAR, S.K. & BUSTARD, H.R. (1981): Crocodile kills taken as human food. *British Journal of Herpetology*. 6: 137.

MESSEL, H. (1977): The crocodile programme in Northern Australia: population survey and numbers. *In: Australian Animals and their environment.* Shakespear Head Press, Sydney.

MESSEL, H., BURBIDGE, A.A., WELLS, A.G. & GREEN, W.J. (1977): The status of the saltwater crocodile in some rivers systems of the north-west Kimberley, Western Australia. Department of Fisheries and Wildlife, Western Australia Report No. 24: 1-50.

MESSEL, H., WELLS, A.G. & GREEN, W.J. (1978): *Crocodylus porosus* population studies. Survey techniques in tidal river systems of Northern Australia. Presented at the 4th Working Meeting IUCN/SSC Crocodile Specialist Group, held at Madras, India. February 6-12.

MESSEL, H., GANS, C., WELLS, A.G., GREEN, W.J., VORLICEK, G.C. & BRENNAN, K.G. (1979): Surveys of tidal river systems in the Northern Territory of Australia and their crocodile populations. Monograph No. 2. The Victoria and Fitzmaurice river systems. Pergamon press (Australia) No. 2:1-52.